UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils
and Agricultural Engineering

H. T. & S. Office Report No. 211

Investigation of Apple Bruising
Wenatchee, Wash. 1948-1949

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Report of a study made under the
Research and Marketing Act of 1946
Project No. 276

July 6, 1949
Wenatchee, Washington

INVESTIGATION OF APPLE BRUISING[1/]

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The objects of the 1948-1949 studies were to determine, (1) the extent of fruit bruising during the handling of picked fruit from the orchard to the time of washing and packing; (2) factors in the cleaning and grading operations that contribute to fruit bruising; (3) the relation of packing bruises to methods and materials used.

METHODS

The work of the picking crews was evaluated in typical orchards of Delicious, Richared and Starking varieties to secure the degree of injury caused by picking. Injuries were classified as severe and slight bruises, and skin punctures. Severe bruises included those that were considered a marked blemish to the appearance of the fruit, and were generally at least one-half inch in one dimension, or a slightly smaller, deep bruise. All other dents or bruises, not readily apparent upon casual examination, but possible openings for decay infection during the washing operation were classified as slight bruises.

Where pallets were used for hauling and handling, the boxes were marked in the orchard and the identical fruits were again examined when received at the packing house, and after removing from cold storage for packing. Fruit from 29 pickers in 6 orchards was included in this phase of the study.

Where individual boxes were hauled and handled from the tree row to a "yarding out" platform and then by road truck to the packing house, identical boxes of fruit were not followed through except in one instance. Instead, comparisons were made between the average of picking bruises for the orchard and bruises present when the fruit was received at the packing shed. Here the boxes from 49 pickers in the orchards of 8 growers were used.

To investigate factors during cleaning and grading, 100 boxes of medium-size Delicious apples were picked with exceptional care so as to be bruise-free and were composited into duplicate samples of 50 fruits for all operations excepting box-dumping for which it was necessary to use full box samples. After subjecting the bruise-free samples to an operation they were examined at the laboratory for injuries received.

1/ Report of a study made under the Research and Marketing Act of 1946. Project No. 276

The relation of packing methods and materials to packing bruises was studied by the careful examination in cold storage plants of commercially packed apples for injuries that were obviously the result of the packing operation. This phase of the study was preliminary in nature and will not be reported in detail.

RESULTS

Picking Bruises

A comparison of bruising following the use of canvas bags and canvas-bottom metal picking buckets is given in Table 1. The ratio of 3.75 to 1 (severe bruises) in favor of the canvas-bottom metal picking buckets should not be credited entirely to the type of bucket because the use of this equipment indicated a consciousness on the part of the growers of the importance of careful handling and in some instances they gave pickers very close supervision.

Extreme differences in the number of picking bruises were observed and reported 2/ and 3/ in 1947. Where excessive picking bruises were found in 1948, picking supervision was inadequate. One packing house employed a checker to inspect samples of every load delivered, and reports on injuries found were promptly sent to the orchard. As a result, picking bruises among the growers concerned were notably low.

Bruises incurred during hauling and handling

With average handling of apples from the orchard to the packing house on pallets there was only 19 percent as much bruising as when the boxes were handled separately. With either manner of handling, the extent of bruising was related to the methods and care used. Data in Table 2 show that hauling individual boxes as studied in the Manson district, resulted in no greater injury than hauling on pallets (Peshastin district). In the latter individual boxes were hauled out of the orchard rows to a "yarding out" platform, then transferred to pallets on the road trucks, and at the packing house the fork-lift truck operators were not as careful as they might have been; pallet loads were rocked and set down rather severely. Even so, the results here were markedly better than in individual box handling in the Wenatchee district. Pallet handling also resulted in fewer skin punctures.

2/ Smith, Edwin, and T. R. Wright. Source of apple bruises. H. T. & S. Office Report No. 190. 1948

3/ Apple Research Digest, Wash. State Apple Com. No. 23. Aug., 1948.

There was practically no increase in the number of either severe or slight bruises resulting from hauling apples on pallets at Oroville; here the boxes were picked up from beneath the trees, placed on pallets riding on low orchard trailers, and hauled directly to the packing house without rehandling. Included in this operation were apples hauled for a mile or more over an unpaved, gravel road. The fork-lift truck operator unloaded the pallets with dexterity and gentleness. In order to haul pallet loads beneath the trees it was necessary that the boxes be stacked only 3 or 4-high instead of the customary 5-high. During the early packing season when plenty of pallets and stacking space were available this did not necessitate increasing stack heights at the packing house. In the Oroville operation pallet dimensions were designed to load the boxes 3 stacks wide instead of the customary 2 stacks wide, the better to use the full width of the orchard trailer beds. This method of handling would be highly recommended wherever feasible were it not for the fact that no study has been made of the refrigeration of three-wide pallet loads, without intervening spaces for air circulation, when they are placed in storage.

Bruises incurred during storage of loose fruit

The handling of palletized boxes of loose fruit during receiving, stacking in cold storage and delivery to the packing line later in the season resulted in only 61 percent as many bruises as where individual boxes were handled. In this comparison both cold storages used were separated from the packing houses. Boxes were stacked 5-high on pallets and the pallets were stacked 3-high in the cold storage. The pallets were transferred from cold storage to packing house by fork-lift truck. Where the boxes were handled individually, they were moved to position by hand truck, stacked 8-high in cold storage and, at time of packing, the stacks were broken down for trucking on and off the motor truck which was used to transfer the fruit from cold storage to packing house.

The data in Table 3 show that the bruising incurred during the storage of the loose fruit was of considerable importance. A comparison of the number of bruises incurred during storage with the number incurred during hauling from the orchard (Table 2) indicates a greater opportunity for bruise reduction during the cold storage rehandling operations than during hauling from orchard to warehouse. This is especially true in handling boxes on pallets where additional bruising in the cold storage of loose fruit is largely dependent upon the skill of the fork-lift operators.

Factors in cleaning and grading related to bruising

Dumping: After apples are brought to the packing line the first opportunity for bruising occurs while dumping the boxes. As shown in Table 4 the manner of dumping has an important relationship

to the number of bruises. A tall operator, giving the boxes a flip with some tossing of the fruit on the dumping table belt, caused 12 severe bruises per 100 apples as against 2 for the careful dumper. Comparable or slightly better results than the latter resulted when an average operator dumped the fruit into a water bath from which it was carried to the washing machine by an endless conveyor. Despite the fact that the apples being dumped hit apples floating in the bath, there were fewer total bruises than when the apples were carefully dumped on a canvas belt passing over a solid surface.

Some packing house operators have installed conveyor belts that place boxes at the level of the dumping table in front of the manual dumper. This eliminates the lifting of fruit by the workman and results in a greater regularity in feeding a line. By thus making the work easier it is possible to get more careful manual dumping.

Of the two types of automatic mechanical dumpers checked, the one handling individual boxes from a conveyor line and having an apron between box and table (Figure 1) gave better results. It will be noted in Table 4 that this mechanical dumper (No. 4) produced fewer bruises than the rough manual dumper but more than the careful manual dumper, whereas the machine that automatically dumped boxes from stacks (Figure 2) was more severe on the fruit than the rough manual dumper. Mechanical dumpers are still in the experimental stage and these studies show that reducing the force of fruit impact in its transfer from box to feed belt is necessary.

Cleaning equipment: Data in Table 5 show a wide variation in the severity and extent of apple bruising as a result of the cleaning process (exclusive of dumping). A number of factors are involved in causing bruises during the cleaning process, and not all of them are readily identified. Machine No. 1 was a very old, dual process washer, largely outmoded because of length and type of progressor, yet it caused fewer bruises than some of the shorter, redesigned single washers. The moderate speed of operation was a factor but possibly not the only one contributing to its comparatively good performance.

The faster speed of single flood washing machines 3 and 4, to secure greater capacity in contrast to single flood machines 5 and 6, very definitely contributed to bruising, especially to an excessively large number of small bruises. Machines 3 and 4 (Table 5) caused multiple dents so numerous they were not recorded but estimated at from 30 to 40 per individual fruit.

Washing machine 8 was built especially to wash Golden Delicious apples and carried the apples on an endless conveyor without impact until they reached the towel drier (Figure 3) which had a conventional "walk-along" progressor. It will be seen in Table 5 that this machine caused almost as many bruises as Machine 9 which had a

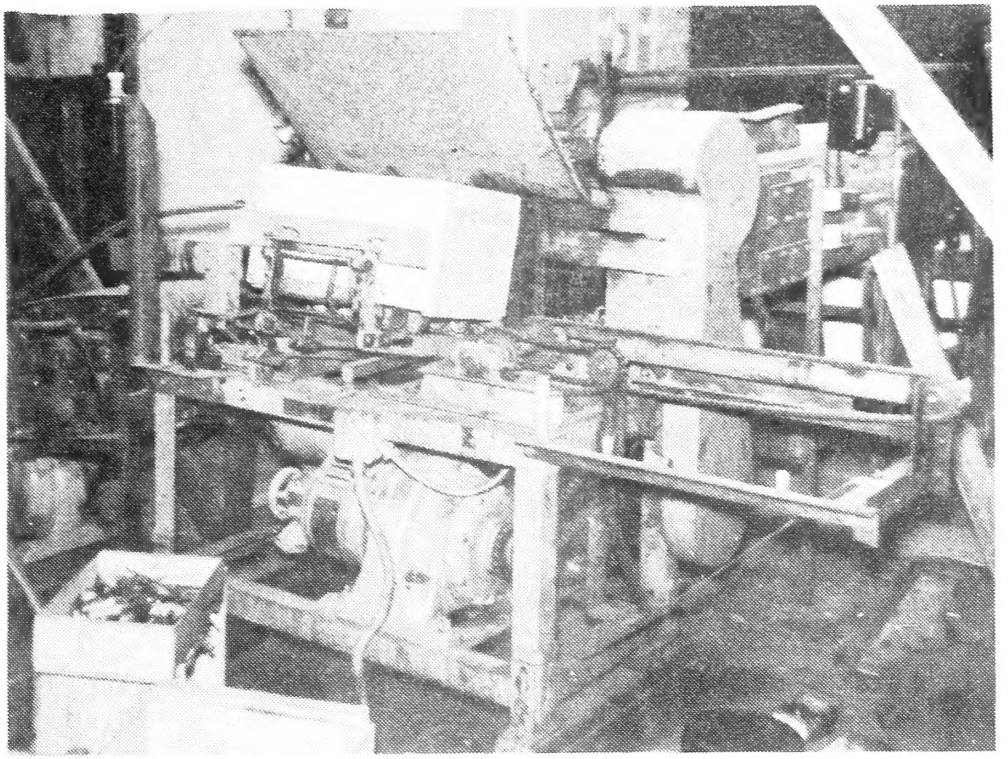

Figure 1. Mechanical dumper with apron handling boxes from a conveyor line.

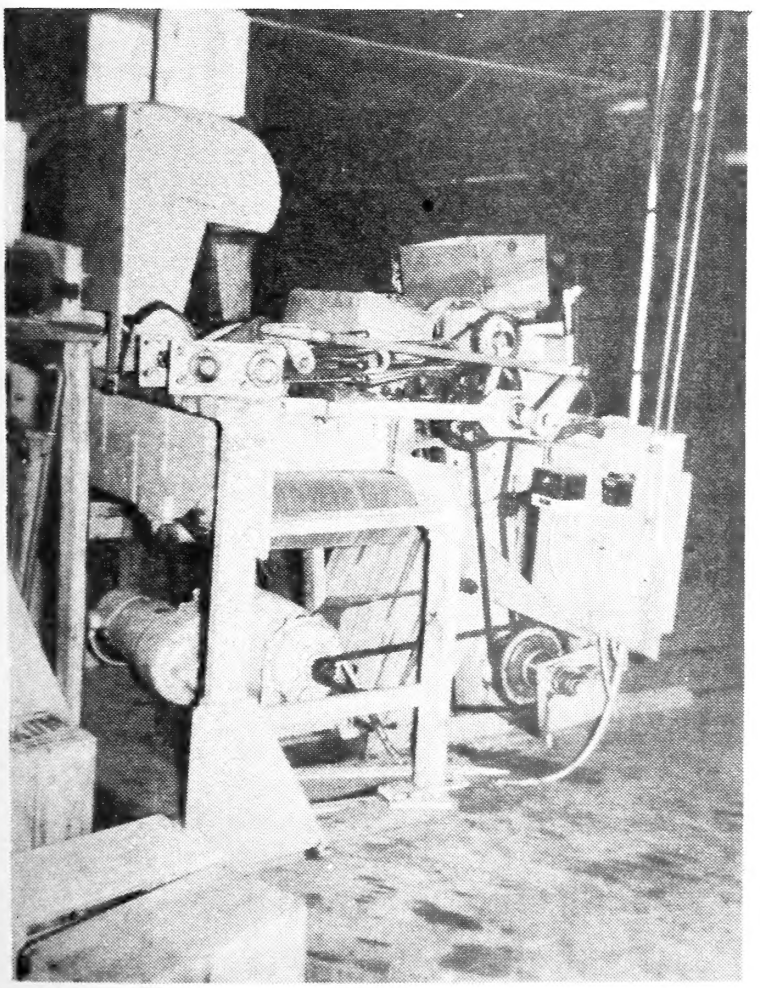

Figure 2. Mechanical dumper completely inverting boxes from a stack. Stacks of six boxes are automatically placed in position by floor chains and elevated for the top box to be in position for dumping.

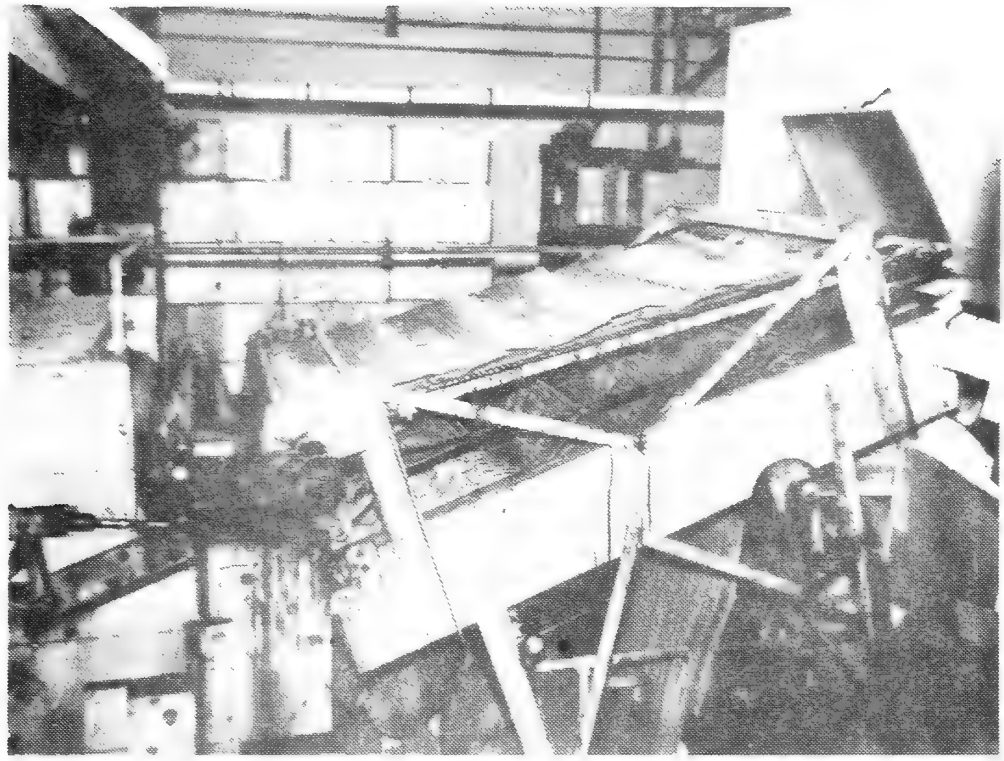

Figure 3. Conventional towel drier.

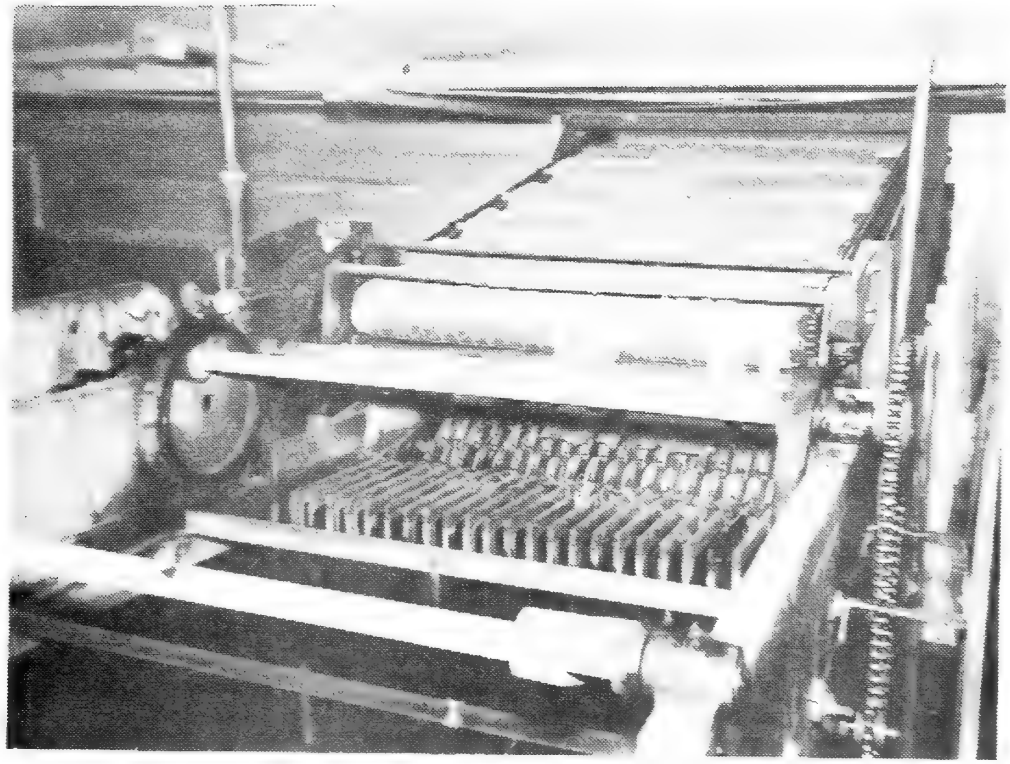

Figure 4. Change of level from flotation washer (No. 10, Table 5) to progressors of towel drier.

"walk-along" progressor with forced air from a blower instead of moving velour towels for drying.

Other instances where the towel drier sections caused bruises that offset the careful handling of apples in the main part of the washers are machines 7 and 10. The former was an experimental machine, designed to handle apples carefully by use of an endless conveyor through the wash; but until changes were made in the towel drier it caused 4 times as many severe bruises as any other machine tested. Machine 10, likewise, should be one to cause little bruising in the washing section, and tests showed that a large part of the bruising was caused beyond the washer section.

Data in Table 6 show that the blower-type drier caused markedly fewer bruises than the towel drier. This machine did not have a change of level between the washing and drier sections. Some of the bruising attributed to towel driers possibly may have been caused at point of transfer from washing section to drier section (Figure 4). A test with machine 7, Table 5, showed that 8 severe bruises per 100 were caused when unbruised apples were placed on the endless conveyor in the washer section, but none were caused when apples were placed on the progressor of the towel drier, indicating that bruising occurred at the point of transfer.

Many of the older washing machines employ a combination elevator-leaf eliminator (Figure 5) between the dumping tables and washing sections. These consist of an endless conveyor with transverse rolls. Newer machines have the dumping table and washer progressor on the same level and a part of the progressor is utilized for leaf elimination (Figure 6). From the data in Table 7 it is evident that the elevating type of leaf eliminator caused many more bruises than the level type.

One of the rag wipers (Machine 11, Table 5) cleaned apples without causing any severe bruises and with a fraction of the slight bruises caused by any of the washing machines. This machine was an old model "Andy Moe" wiper (Figure 7). The owner had cushioned the conveyor rolls with a canvas covering and had made special provision for the careful handling of fruit. Machine 12, a rag wiper with underneath hair brushes (Figure 8) was more severe than most washing machines. This was a new machine but its design and assembly, as well as its installation, left much to be desired. It will be noted in Table 5 that bruising was reduced by about 25 percent after a few temporary alterations had been made in this machine.

Sorting and sizing equipment

The simplest sorting and sizing equipment and the one requiring the most labor consists of a belt from which a worker selects apples for size and grade, then places them into one of a series of packing bins. Few of these machines remain in use as the sizing of apples is nearly all done by Cutler weight-type graders, which generally have rotary bins.. In belt sorting the tables are varied between belts (Figure 9) from which all fruits have to be picked up and placed on another belt carrying a single grade. Spiral rolls are sometimes used instead of the moving belt. These are wooden rolls spirally wound with rope to progress and turn the apples (Figure 10). The latter requires the least labor because only a part of the apples have to be transferred by hand.

As the apples move from the sorting table to the sizing cups there are two mechanical operations that affect bruising. First, the apples are progressed in a single line either by a narrow belt or singulator. The latter consists of two short rolls spirally wound with rope similar to spiral sorting rolls. By means of the singulator, apples are deposited in cups that rotate on a shaft, designated as a "distributing roll". As the distributing roll rotates, single apples are deposited in moving sizing cups. Singulator, distributing roll and sizing cups are illustrated in Figures 11 and 12.

If the singulator rolls are synchronized with the distributing roll every apple will be placed accurately in a cup of the distributing roll. If not, the apple will strike the edge of the rotating cup and receive a bruise. Where single line belts are used instead of a singulator a part of the apples will land accurately in a cup and part will strike a moving edge. Also if the distributing rolls are not accurately timed with the moving sizing cups, apples will strike the metal frame supporting the canvas of the cup and bound into place, causing a slight bruise. The timing of the singulator, distributing rolls and canvas sizing cups appears to be very important in bruise prevention.

Tests with grading and sizing equipment showed (Table 8) that the fewest bruises followed the use of the belt table with hand grading and sizing. Careless workers might show worse results. Belt sorting with a singulator between sorting table and sizer gave the next best results, followed by a sorting belt without singulator. The comparatively large number of bruises when spiral rolls were used (Nos. 4 and 5, Table 8) is ascribed largely to faulty adjustment and operation of sizing equipment. Further studies of the human as well as of the mechanical phase of apple sorting is suggested by these data. The relation of the position and dexterity of the sorters, the effect of over-taxing the equipment and alignment of spiral ropes are factors not covered in this study.

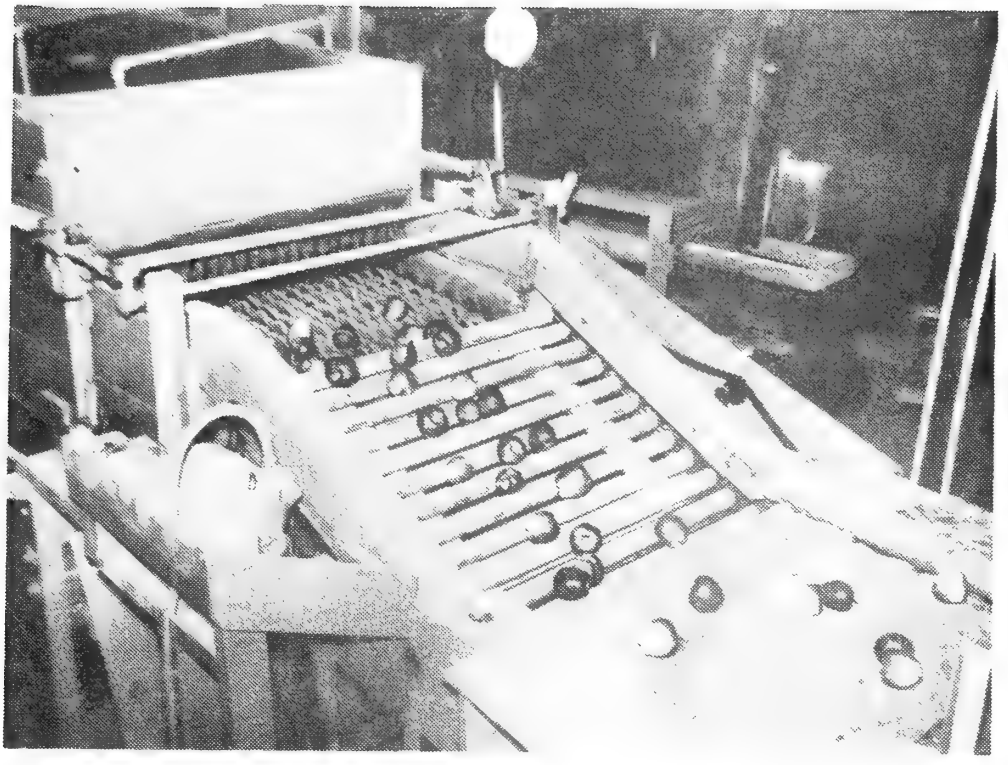

Figure 5. Leaf eliminator-elevator, consisting of an endless conveyor with transverse rolls.

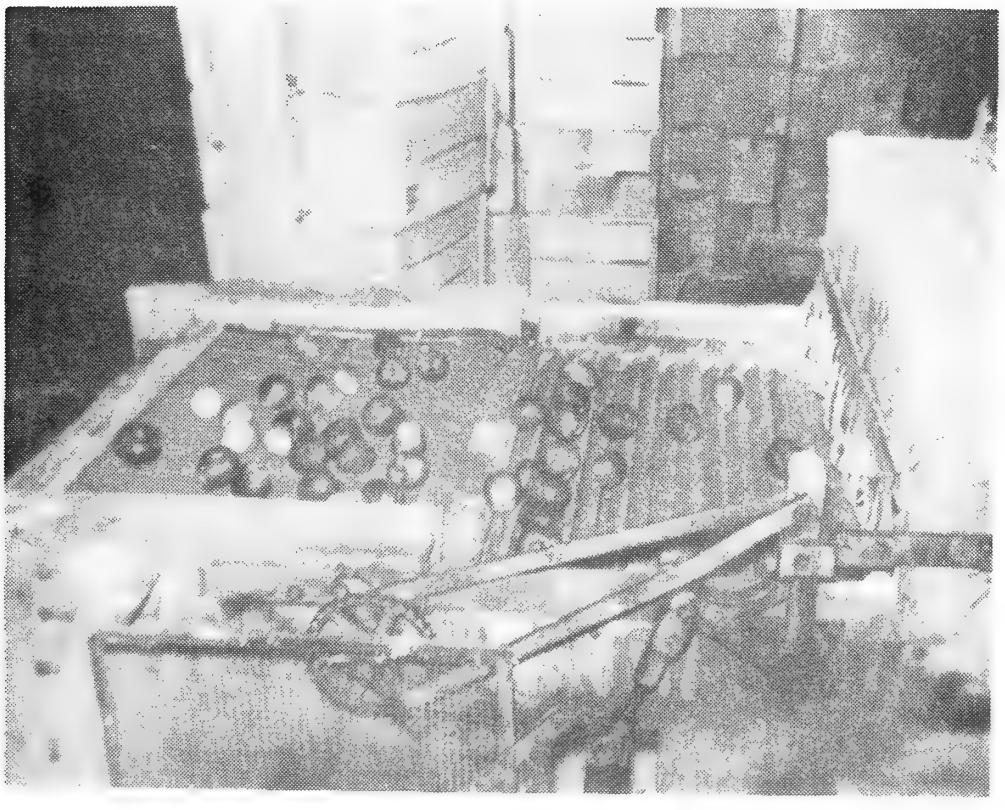

Figure 6. Leaf eliminator consisting of "walk-along" progressor on the same level as dumping table and washer, caused fewer bruises than conveyor with rolls.

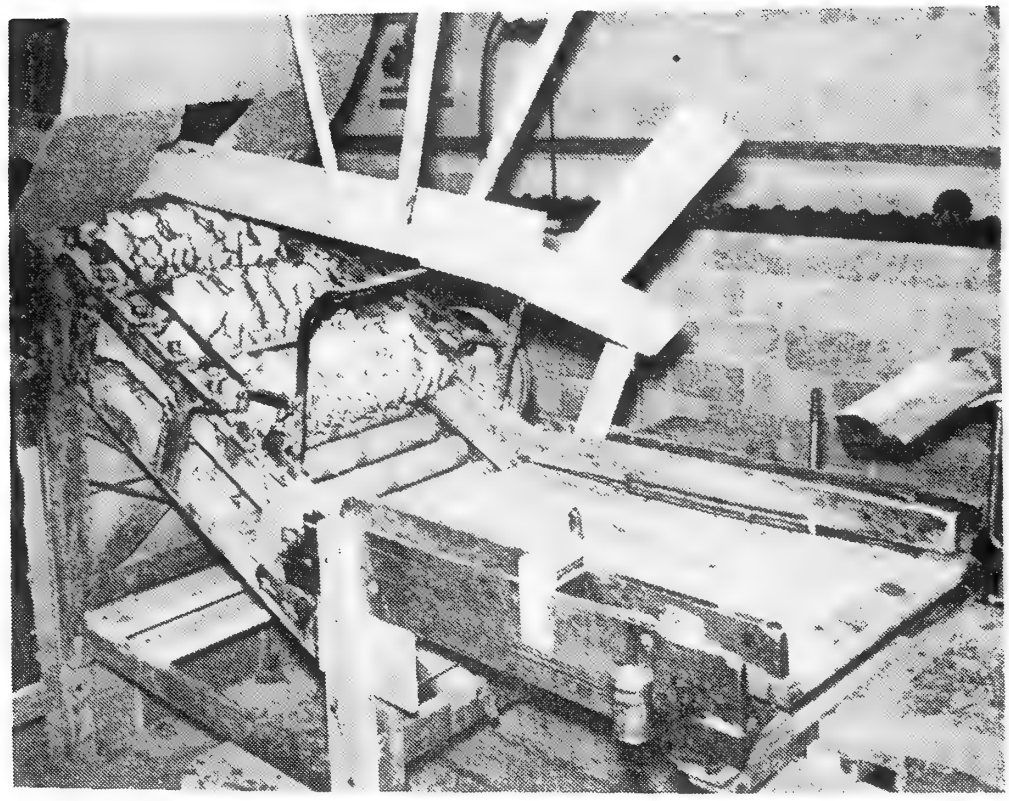

Figure 7. Andy Moe rag wiper carefully installed caused few bruises. Note that underneath rolls are cushioned with canvas.

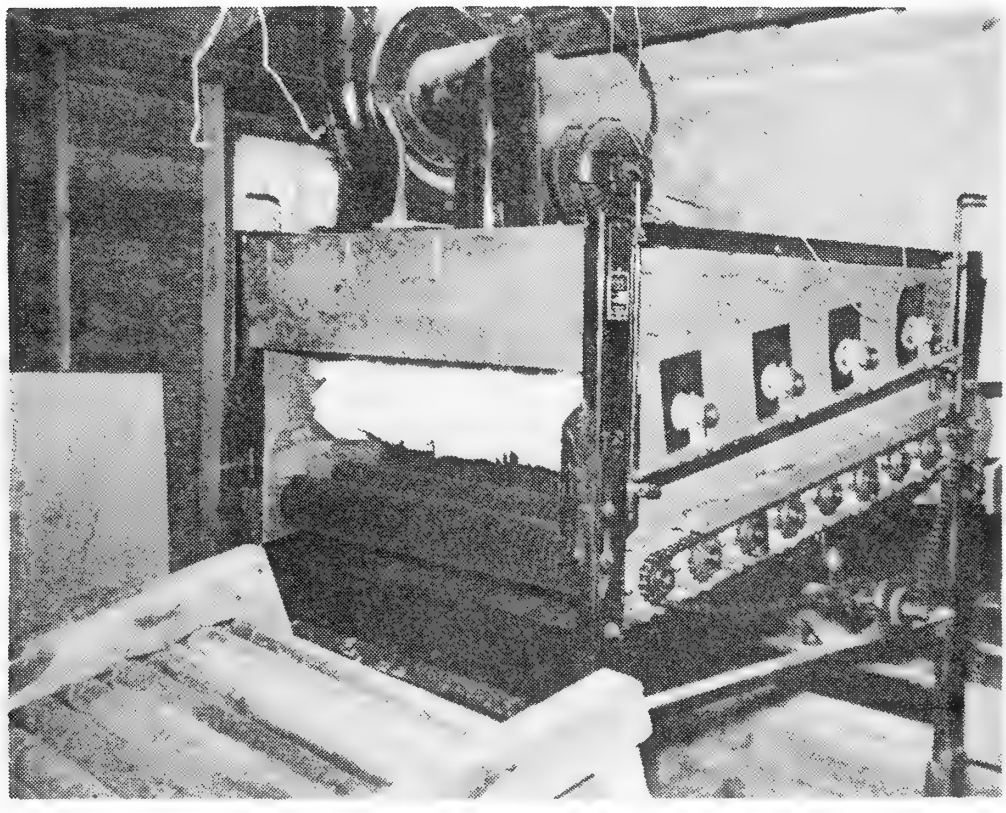

Figure 8. Rag wiper with underneath brushes.

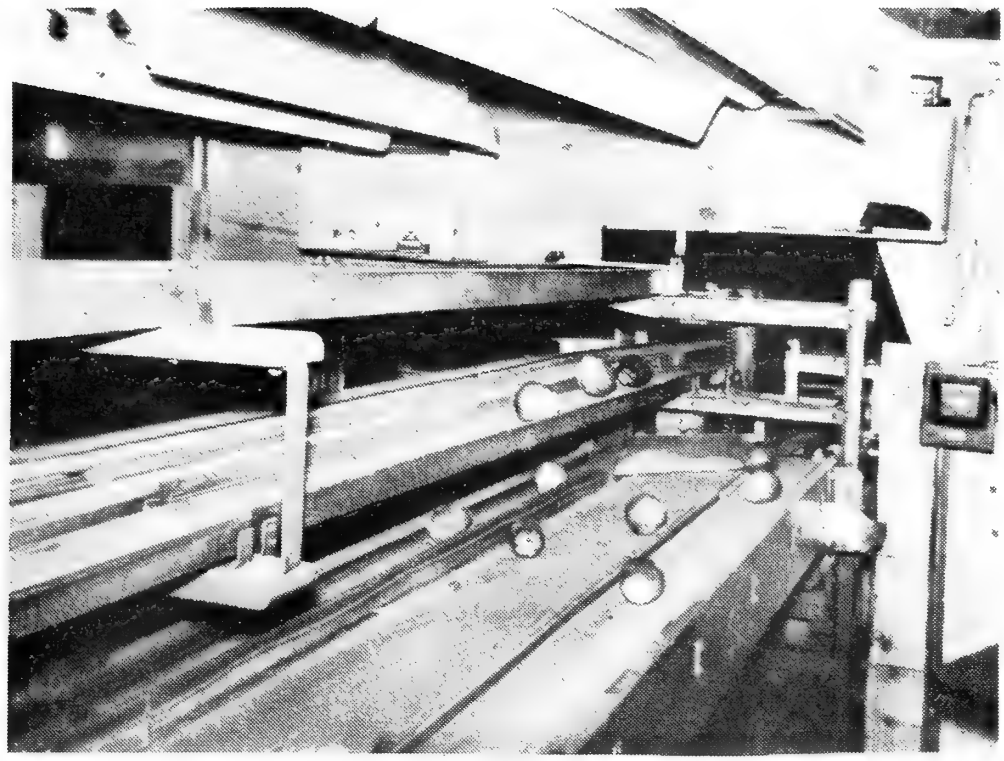

Figure 9. Belt sorting table.

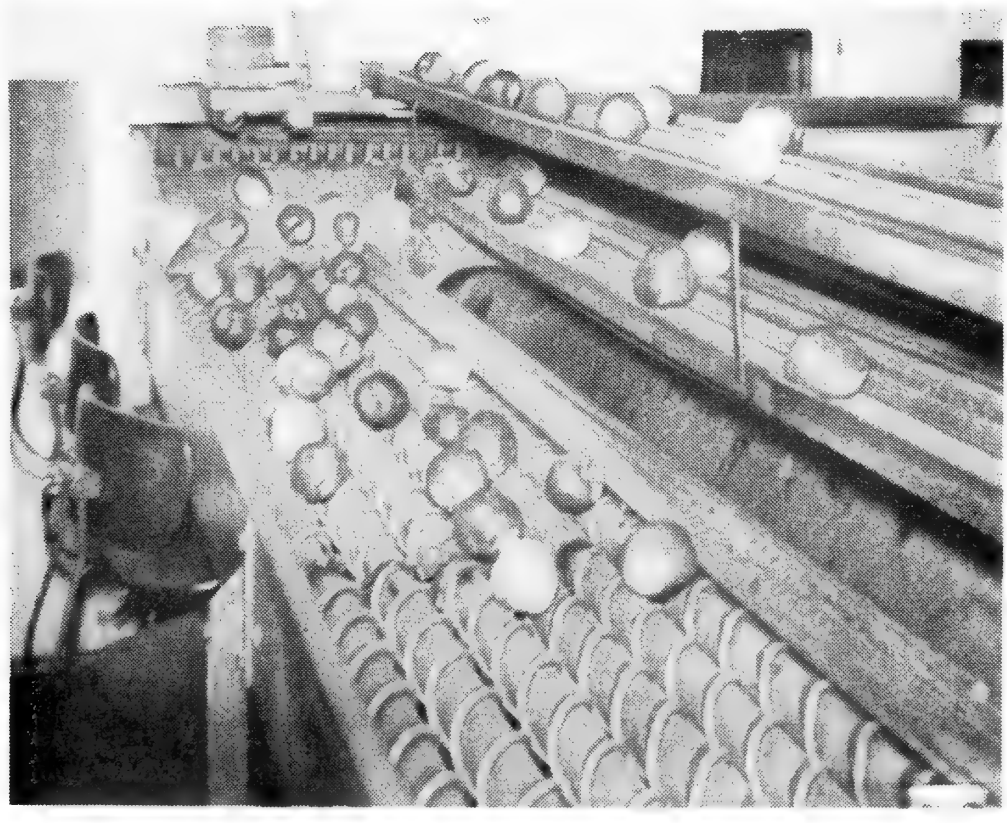

Figure 10. Spiral rolls in a sorting table.

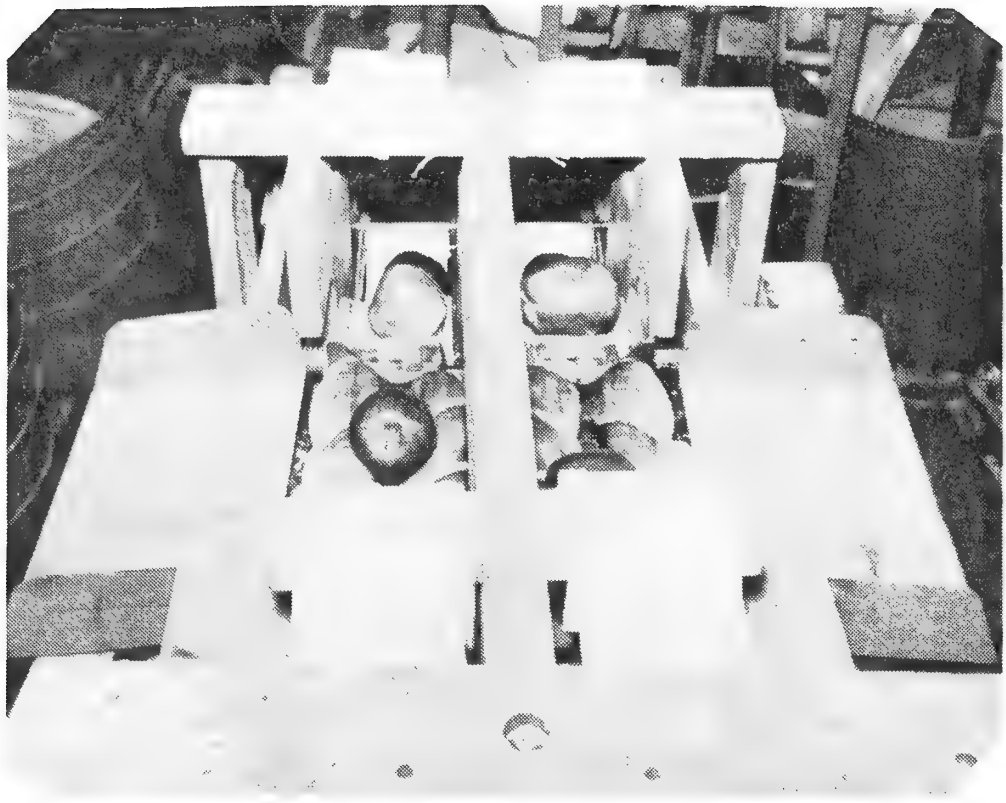

Figure 11. Singulator, distributing roll and sizing cups of a Cutler grader. It is important that these three moving parts be accurately timed to avoid fruits hitting edges of the distributing roll and the metal frame of the sizing cups.

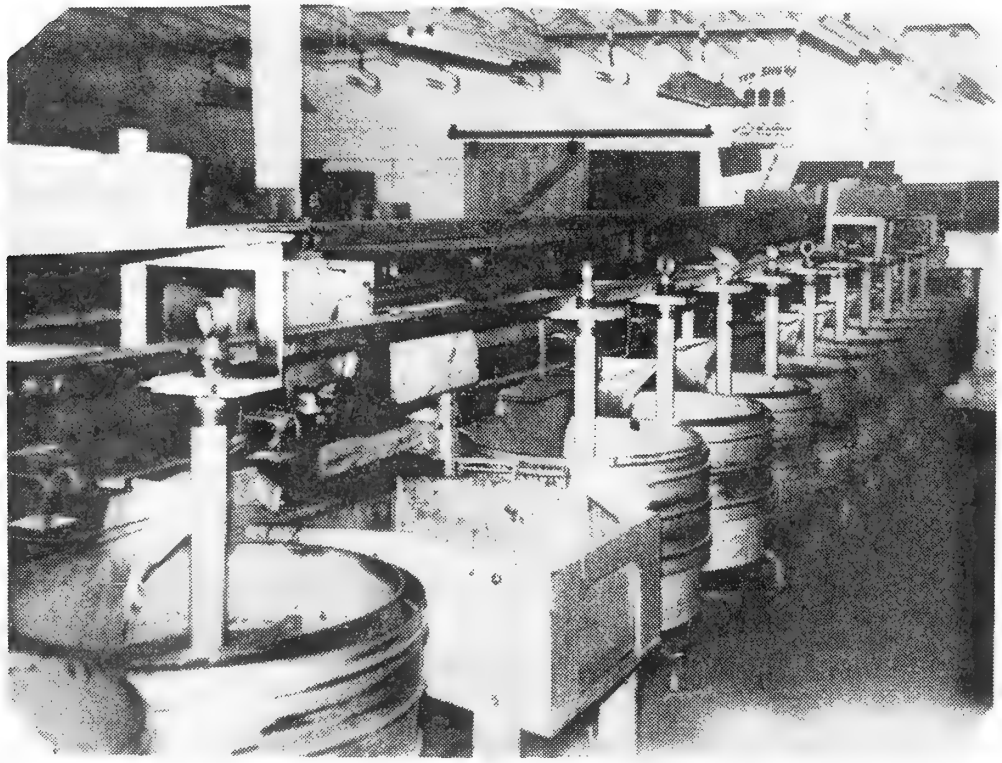

Figure 12. As the apples move from the sorting table, behind partition in background, the Extra Fancy grade go through the singulator of the first sizing section. The Fancy grade is carried on a canvas belt above this section to the singulator of the 2nd section which places them on the canvas sizing cups of the 2nd section. The canvas sizing cups drop them in the rotary bins.

Control measures

Data in Tables 3 to 8 show that a fertile field for bruise reduction lies within the apple packing house. Within the limits of these studies it appears that after apples are brought to the packing line the bruising damage is greater than in the combined operations of picking, hauling and handling. If supervision of picking to prevent bruising is important, the adequate inspection and supervision of packing house operations are of much greater importance.

Use of washing machine No. 5 (Table 5) and grading equipment No. 2 (Table 8) resulted in comparatively few bruises. They were in the same packing house and were not radically different in general design from equipment in other packing houses where more bruising occurred. Adequate supervision, including the determination of the causes of bruising and the correction of faults found, is fundamental to bruise control during fruit cleaning and grading.

These studies suggest the following important points for checking and possible correction:

1. Impact during manual or mechanical dumping.

2. Change of levels between leaf eliminator and washing machine, between washing machine and drier, and between drier and sorting table. The roller-type leaf eliminator or elevator and endless conveyors frequently cause apples to drop several inches at point of delivery.

3. Transfer of apples from drier to sorting table. Frequently the incline delivery is steep (Figure 10) to accommodate the handling of pears, but when used for apples a momentum is induced that causes bruising as the fruit reaches the sorting table. In a few instances observed, the use of a section of belt has reduced the incline and momentum.

4. Alignment of the rope spirals on sorting rolls. It should be aligned so that fruits are progressed without jumping or pinching.

5. Synchronization of the singulator spirals with the distributing roll of the sizing machine. It should be synchronized so that fruits are not hit by the edges of the rotating cups.

6. Timing of the distributing roll with the canvas sizing cups. It should be timed so that apples are deposited on the center of the canvas and do not strike the metal framework.

7. Condition of the canvas aprons used to check the impact of apples dropping from the sizing conveyor into the rotary bins. These may become worn so short as not to serve their intended purpose.

8. Cushioning on the bottoms of the rotary bins. The four radiating cleats on the bottom of the bins should be removed or cushioned as they present a bruise hazard.

9. Assembly and installation faults. A careful inspection of each cleaning-packing line is very important to detect faults incident to its assembly and installation.

The relation of packing methods and materials to bruising

An examination of packed fruit from various storage plants indicated that those bruises obviously resulting from pressure between fruits or between a fruit and the package varied greatly between packing houses, irrespective of packing material. The data, however, are not conclusive since it was not possible to secure enough packages by an individual packer with different packaging materials, such as liners, 4-way pads and tier-layer-pads to draw a distinction between the skill of the packer and the material used with respect to the number and severity of bruises found.

Where the gross weight of packed Delicious and Winesap apples in wood boxes was over 50 lbs. the number of bruises was usually greater than where gross weights were between 48 and 50 lbs., and where gross weights were less than 48 lbs. the bruise count was still smaller. "Heavy packing", therefore, is likely to cause heavy bruising damage. However, the full extent to which this relationship between weight of packs and number of bruises holds after the packages have undergone transportation and market distribution remains to be determined.

Table 1. Bruises incurred during picking. 1/
1948

Type of picking container	Orchards Checked	Fruits Checked	Bruises per 100 fruits		
			Severe	Slight	Total
Canvas bags	10	7172	3.75	22.1	25.8
Metal, canvas bottoms	4	2179	1.0	20.5	21.5

1/ Delicious, Richared and Starking varieties. Identical pickers did not use the different container types.

Table 2. Injuries incurred during hauling loose apples. 1948

Handling Method	Growers Checked	Fruits Checked	Injuries caused per 100 fruits			
			Skin punctures	Bruises		
				Severe	Slight	Total
By individual boxes, Manson	3	3725	0.5	0	15.8	15.8
By individual boxes, Wenatchee	5	5584	1.2	5.9	54.9	60.7
On pallets from tree row. Oroville	3	5510	0.1	0.4	1.4	1.8
On pallets from roadside, Peshastin[1/]	3	3768	0	1.6	14.1	15.7
Individual boxes, both districts	8	9309	1.1	3.3	37.4	40.7
On pallets, both districts	6	9278	0.1	0.9	6.8	7.7

1/ Yarded out of orchard as individual boxes; careless handling with warehouse fork-lift trucks.

Table 3. Injuries incurred during storage of unpacked apples. 1948.

Handling Method	Fruits Checked	Injuries caused per 100 fruits			
		Skin punctures	Bruises		
			Severe	Slight	Total
By individual boxes	3972	0	8.8	43.4	52.2
On pallets[1/]	3152	0	5.9	26.3	32.2

1/ Careless handling with fork-lift trucks.

Table 4. Bruises caused by dumping apples. 1948.

No.	Method	Packing house	Percent apples bruised	Average bruises per 100 fruits.		
				Severe	Slight	Total
1.	Manual, rough	B	65	12	109	121
2.	Manual, careful	B	40	2	55	57
3.	Manual, in water tank	J	41	1	48	49
4.	Automatic, single box type	B	65	7	87	94
5.	Automatic, from box stack	C	93	14	145	159

Table 5. Bruises caused by cleaning equipment, exclusive of dumping. 1948.

Machine Number and type	Packing house	Speed S.P.M. [1]	Percent apples bruised.	Average Bruises per 100 fruits		
				Severe [2]	Slight [3]	Total
1. Dual flood, old type progressor [4]	A	42	64	5	77	82
2. Dual flood, late progressor	B	38	100	7	314	321
3. Single flood, line 3	C	58	97	3	300 [5]	303
4. Single flood, line 2	C	58	75	8	146 [5]	154
5. Single flood	D	44	58	6	88	94
6. Single flood, rebuilt	E	44	84	2	180	182
7. Single flood, endless conveyor, Exp.	F		67	36	98	124
7. After changes in drier	F		72	8	96	104
8. Single flood, endless conveyor	C		48	0	63	63
9. Single flood, air drier	B		50	1	72	73
10. Single flotation, lift progressor	F		99	9	227	236
10. Towel drier alone	F		89	7	219	226
11. Dry wiper - canvas over rolls	G		11	0	13	13
12. Dry wiper - canvas over brushes	H		83	14	116	130
12. After slight alterations	H		62	10	83	93

1/ S.P.M. Strokes per minute of progressor.

2/ Bruises at least 1/2 inch at greatest dimension - considered visible blemish.

3/ Any dent - possible point of decay invasion.

4/ "Shuffle board" progressor in contrast to longitudinal type.

5/ Numerous multiple-dents not counted, running 30 to 40 per apple.

Table 6. Bruises caused by washing machine driers. 1948.

No.	Type	Packing house	Percent apples bruised	Bruises per 100 fruits		
				Severe	Slight	Total
1.	Towel from flotation washer	F	89	7	219	226
2.	Towel from endless progressor	F	70	8	88	96
2.	After transfer from progressor	F	64	0	72	72
3.	Air	B	37	2	46	48

Table 7. Bruises caused by leaf eliminator. 1948

No.	Method	Packing house	Percent Apples Bruised	Bruises per 100 fruits		
				Severe	Slight	Total
1.	Transverse roller elevator	C	64	8	102	110
2.	Transverse roller elevator	C	82	17	200	217
3.	Level, shuffle board progressor	E	42	0	48	48

Table 8. Injuries during grading and sizing.

1948.

Machine No.	Equipment type	Skin punctures Percent	Fruits bruised percent	Bruises per 100 fruits		
				Severe	Slight	Total
1	Belt-Hand sizing and grading	2	43	0	46	46
2	Belt with singulator Cutler sizer, House C	0	56	6	59	65
3	Belt no singulator Cutler sizer - House B	0	72	9	121	130
4	Spiral rolls, singulator Cutler sizer, Line 2, House B	1	91	27	219	246
5	Spiral rolls, singulator Cutler sizer, Line 3, House B	0	95	23	273	296
5	From singulator to sizing cups, Line 3	0	90	10	157	167
5	From sizing cups[1/] to rotary bins, Line 3	0	77	26	107	133

1/ Fruits falling in empty rotary bins; canvas aprons worn short.